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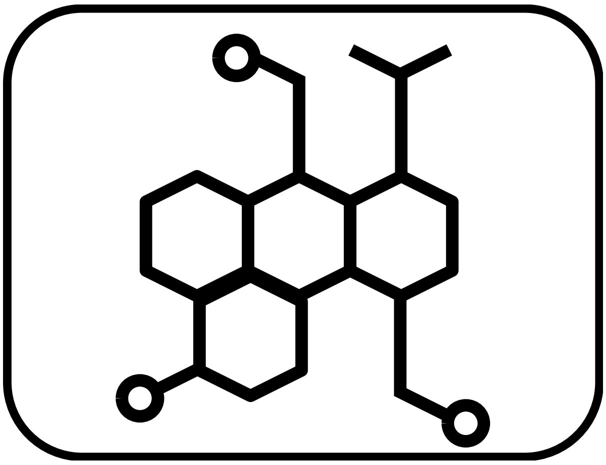
A152

Material structure
Foundational knowledge article



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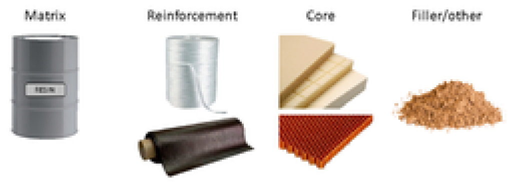
Tags	• Matrix • Reinforcement material

Overview[edit | edit source]

Solid materials are categorized into basic group classifications defined by their chemical makeup and atomic structure [1]. They fall into three basic classifications: metals, ceramics, and polymers. Composite materials are by definition a mix of two or more distinct material classes.



Constituents comprising a fibre reinforced polymer matrix composite material.

The two main material constituents, or parts, that comprise a composite material are the matrix and the reinforcement. Additional materials such as a core and matrix filler materials may also be integrated into the composite material.

Polymer (Matrix) Structure[edit | edit source]

Link to main Polymer (matrix) structure page

For composite materials, the function of the matrix component is to hold in place the load bearing reinforcement fibres, and assist in the load transfer between them. Other functions of the matrix include: supporting the reinforcement in compression (in the case of fibres), and protecting the reinforcement from the environment with moisture and chemical resistance. Polymers are a popular choice for matrix material in combination with glass or carbon reinforcement fibres.

Popular polymer matrix materials include:

- Epoxy (thermoset)
- Polyester (thermoset)
- Polypropylene (thermoplastic)
- Polyethylene (thermoplastic)

On the polymer (matrix) structure page, you will find a general overview about polymer materials, and links to learn more about thermoset and thermoplastic polymers.

To learn about resin matrix materials:

- Click here to view the KPC AIM Event: Composite materials engineering webinar session 3 - Constituent materials - Resin

Reinforcement Structure[edit | edit source]

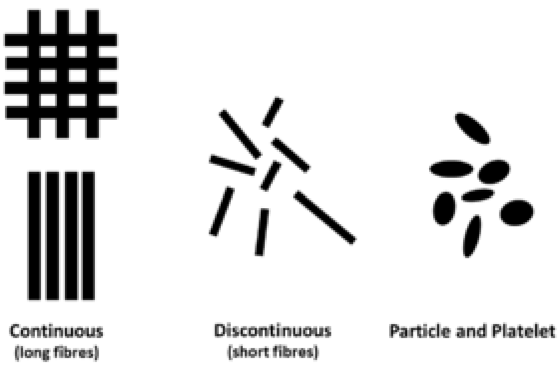


Illustration of the various reinforcement forms available: continuous (long fibre - unidirectional and woven), discontinuous (short fibre), particle and platelet.

Link to main Reinforcement Structure page

The choice of the reinforcement form (size and shape) is important, with each having different mechanical behaviour on its own and influence in the composite material. The choice of reinforcement form is generally dependent upon the application. In addition, each reinforcement form also has its own composite manufacturing considerations.

The common reinforcement material forms are:

- Continuous fibre reinforcement
- Discontinuous fibre reinforcement
- Particle and platelet reinforcement

See the catalogue volume reinforcement page here, for commercially available reinforcement materials and their suppliers.

To learn about fibre reinforcement materials:

- Click here to view the KPC AIM Event: Composite materials engineering webinar session 2 - Constituent materials - Fibre

Composite Structure[edit | edit source]

Link to main Composite structure page

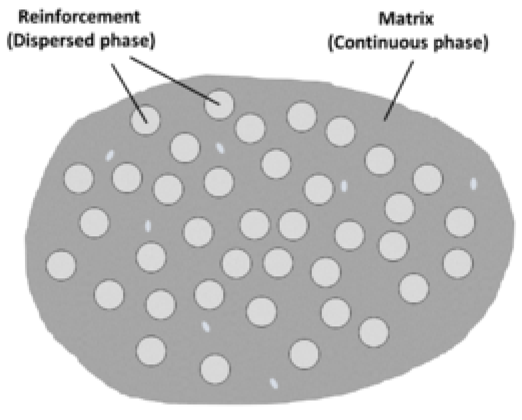


Illustration of the composite material constituent phases. (Matrix - continuous phase, Reinforcement - dispersed phase)

Uniting all the individual material constituents together forms the composite material. It is comprised of the two main components:

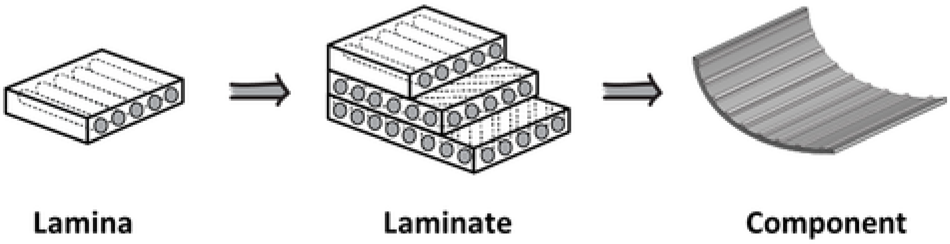
- **Reinforcement** material (the load bearing material)
- **Matrix** material (the binding / hold everything together material)

Other materials that may make up and add function to the composite include:

- Core materials (for sandwich panel structures)
- Matrix fillers and tougheners
- Interphase materials such as fibre sizing
- Other auxiliary materials such as fixation inserts, copper mesh, etc.

Laminate structure[edit | edit source]

Composite materials are typically constructed by laminating, or stacking layers of material (lamina) on top of each other. The individual layers are then arranged at various angles to provide stiffness and strength in desired directions. The term "laminate" is often used to refer to a composite material, particularly for fibre reinforced polymers (FRPs), originates from this lamination structure approach that is typically used to construct composite materials.



Composite materials are typically constructed by laminating, or stacking layers of material (lamina) on top of each other that build up to the desired material structure.

The ability to tailor each layer of the material while building up the component or structure – gives composite materials great flexibility for optimizing the reinforcement orientation for specific load paths in the constructed component.

To learn about the mechanics of laminated composites:

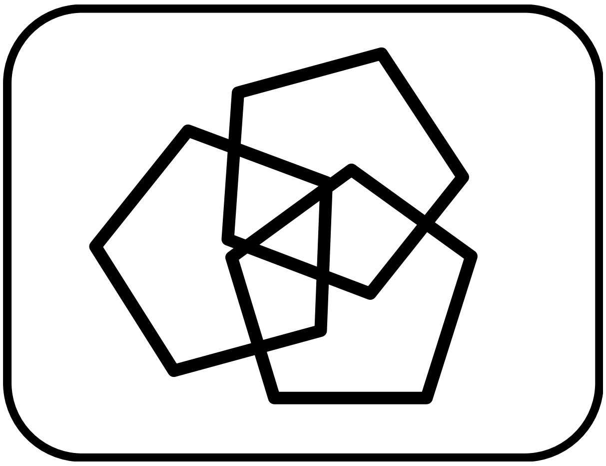
- Click here to view the KPC AIM Event: Composite materials engineering webinar session 8 - Mechanics of composites - Part 1: Lamina level
- Click here to view the KPC AIM Event: Composite materials engineering webinar session 9 - Mechanics of composites - Part 2: Laminate level

Explore this area further

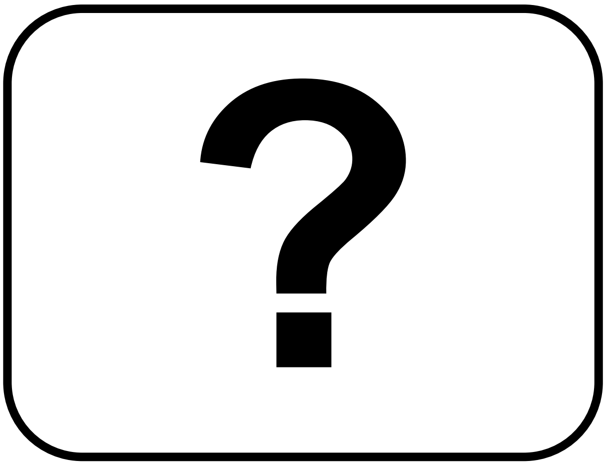
- Material structure - A152
    - Polymer (matrix) structure - A236
        - Thermoplastic polymers - A161
        - Thermoset polymers - A105

References

1. ↑ [Ref] Callister, William D. (2003). *Materials Science and Engineering: An Introduction*. John Wiley & Sons, Inc. ISBN 0-471-13576-3.



About



Help

The continuous material phase that binds the reinforcement together, maintains shape, transfers load, protects the reinforcement from environment and damage, and provides the composite support in compression.

Desirable characteristics:

- Moisture/chemical resistance
- Low density
- Processability

Engineered materials (designed to have specific properties) made from two or more constituent materials with different physical or chemical properties. The constituents remain separate and distinct on a macroscopic level within the finished structure.

A class of polymer, some common examples include polypropylene and polyethylene.

They soften and melt upon heating (i.e. potentially recyclable), high viscosity when melted, therefore difficult to saturate fibres. Usually needs a lot of pressure and heat to process.

Thermosets are a class of polymer that undergo polymerization and crosslinking during curing with the aid of a hardening agent and heating or promoter. Initially they behave like a viscous fluid. During curing, they change from viscous fluid to rubbery gel (viscoelastic material) and finally glassy solid.

If heated after curing, initially they become soft and rubbery at high temperatures. If further heated, they do not melt but decompose (burn)

Comes in two parts: part A (resin) and B (hardener). When mixed, curing reaction starts and is not reversible.

Examples include epoxy or polyester.

For polymer matrix composites (PMCs), resin refers to the matrix; the continuous material phase that binds the reinforcement together, maintains shape, and transfers load. Resins are divided into two main groups: thermosets and thermoplastics.

Sizing or fibre sizing refers to a coating that is applied to fibre during manufacturing. Highly proprietary (formulation and process).

Sizing serves two functions:

- Protects and aids fibre during processing
- Aids in the bonding of fibre and matrix